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(54) **CHARGE AND DISCHARGE CONTROL CIRCUIT HAVING AN INTERMEDIATE TERMINAL DISCONNECTION DETECTING CIRCUIT FOR DETECTING DISCONNECTION WITH SECONDARY BATTERIES**

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***H02J 7/00*** (2006.01)

(52) **U.S. Cl.**
CPC ..... ***H02J 7/0031*** (2013.01)

(58) **Field of Classification Search**
USPC ..... 320/118
See application file for complete search history.

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(57) **ABSTRACT**

The present invention provides a charge and discharge control circuit and a battery device capable of detecting an intermediate terminal disconnection without causing the balance between battery voltages to collapse and shortening the service life of the battery device. A charge and discharge control circuit which controls charging/discharging of a plurality of secondary batteries connected in series is equipped with intermediate terminal disconnection detecting circuits each of which is provided between a positive electrode terminal and a negative electrode terminal of each secondary battery and detects an intermediate terminal disconnection of each intermediate terminal by intermittently equal detection currents.

**4 Claims, 3 Drawing Sheets**

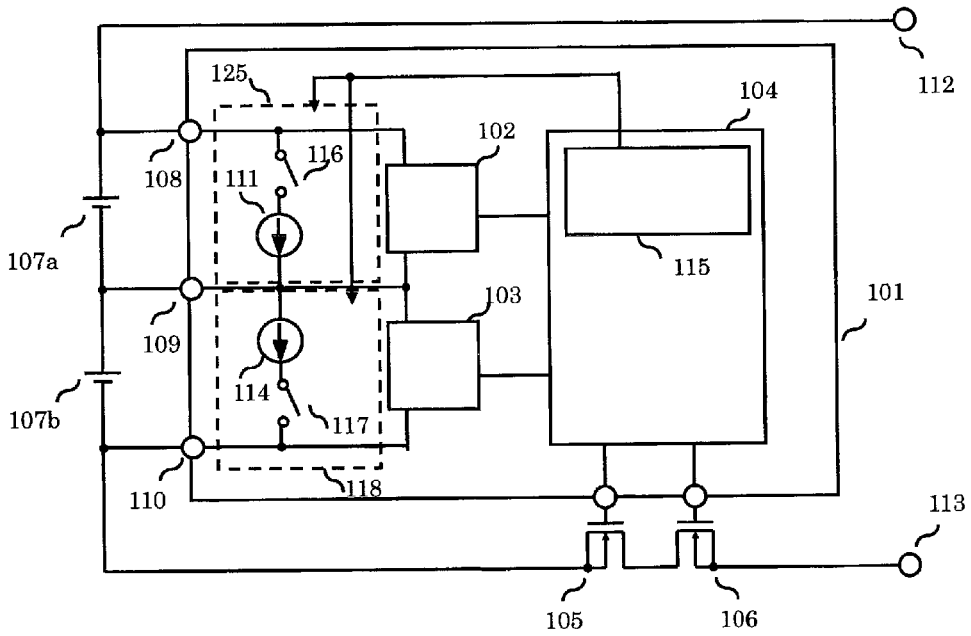


FIG. 1

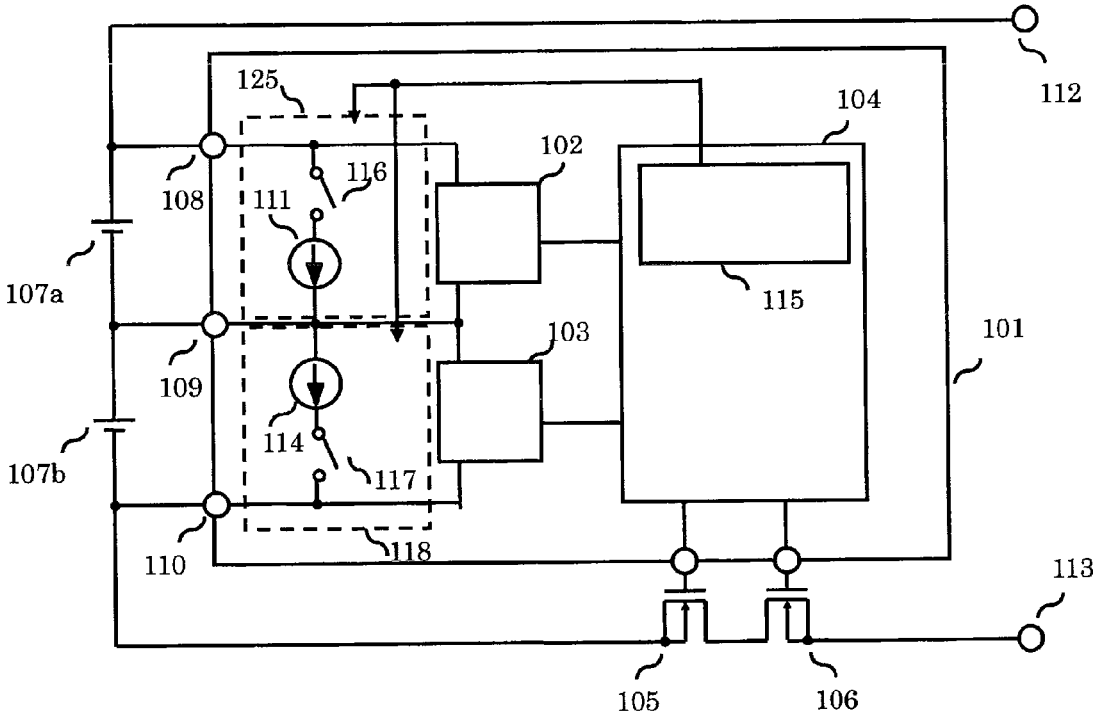

125
112
104
102
108
116
111
107a
115
101
103
109
114
107b
117
110
118
113
105
106

FIG. 2

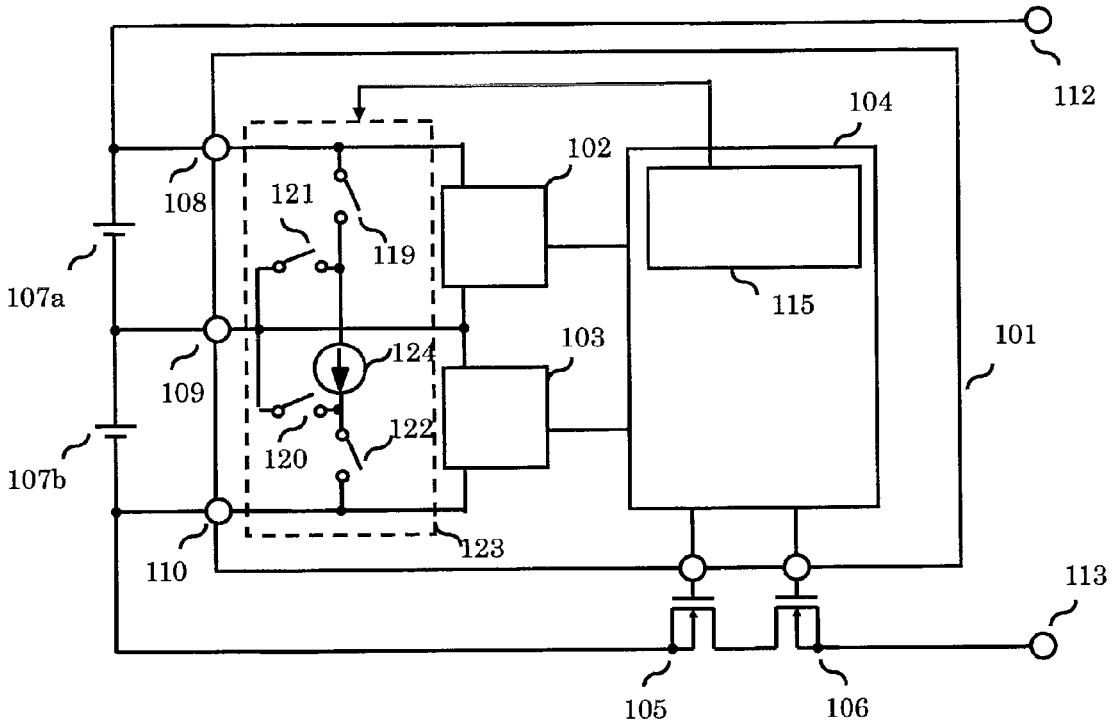
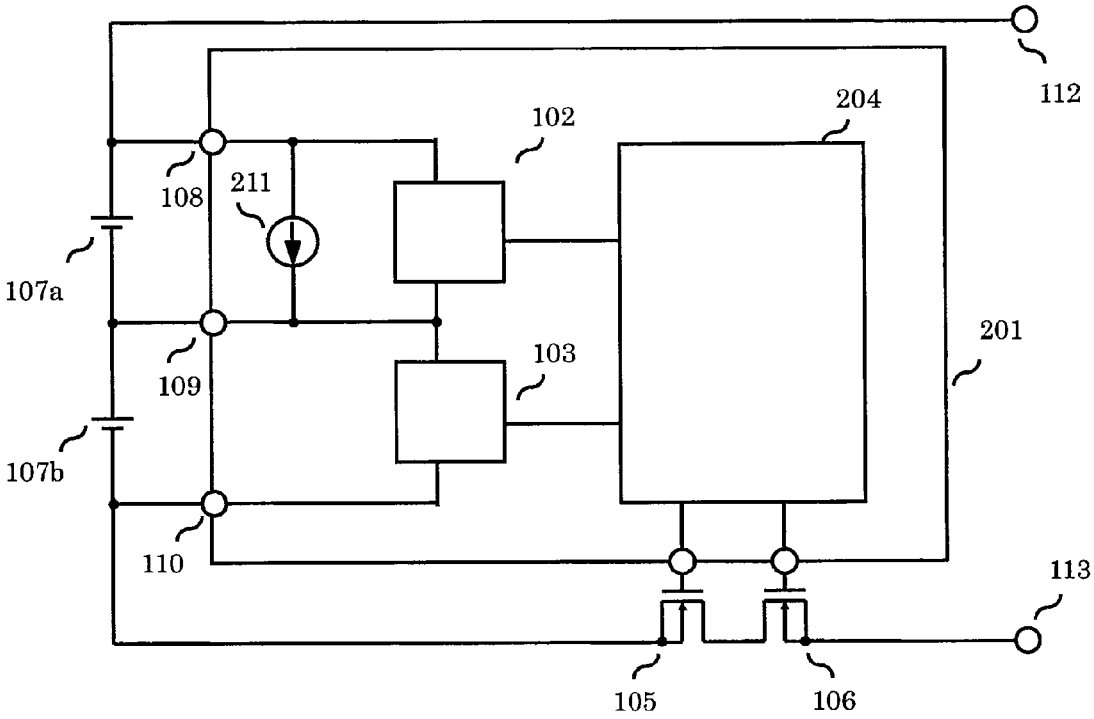

112
104
102
108
121
119
115
107a
103
101
124
109
122
120
107b
110
123
113
105
106

FIG. 3

PRIOR ART



# CHARGE AND DISCHARGE CONTROL CIRCUIT HAVING AN INTERMEDIATE TERMINAL DISCONNECTION DETECTING CIRCUIT FOR DETECTING DISCONNECTION WITH SECONDARY BATTERIES

## RELATED APPLICATIONS

This application claims priority under 35 U.S.C. §119 to Japanese Patent Application No. 2013-121036 filed on Jun. 7, 2013, the entire content of which is hereby incorporated by reference.

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a plurality of secondary batteries connected in series, a charge/discharge control circuit equipped with an intermediate terminal disconnection detecting circuit for detecting disconnection with the secondary batteries, and a battery device.

2. Background Art

In a battery device equipped with a plurality of secondary batteries connected in series, when disconnection (hereinafter called intermediate terminal disconnection) of a connecting portion of each secondary battery and a charge/discharge control circuit occurs, it is not possible to perform charge/discharge control of the secondary batteries. That is, there was a problem that though the secondary batteries were in overcharge or overdischarge, it could not be detected, thus giving large stress to the secondary batteries. Therefore, there has been proposed a battery device equipped with an intermediate terminal disconnection detecting circuit for the purpose of detecting the intermediate terminal disconnection to thereby enhance safety of the secondary batteries.

A circuit diagram of a battery device equipped with a related art intermediate terminal disconnection detecting circuit is shown in FIG. **3**. The battery device includes secondary batteries **107***a* and **107***b*, a charge control FET **106**, a discharge control FET **105**, external terminals **112** and **113**, and a charge/discharge control circuit **201**.

The charge/discharge control circuit **201** is composed of a positive power supply connection terminal **108** to which a positive power supply of the secondary battery **107***a* is connected, an intermediate terminal **109** connected to a connecting point of a negative power supply of the secondary battery **107***a* and a positive power supply of the secondary battery **107***b*, a negative power supply connection terminal **110** to which a negative power supply of the secondary battery **107***b* is connected, a voltage detection circuit **102** for monitoring the voltage between the positive power supply connection terminal **108** and the intermediate terminal **109**, a voltage detection circuit **103** for monitoring the voltage between the intermediate terminal **109** and the negative power supply connection terminal **110**, a control circuit **204** for outputting signals for controlling the charge control FET **106** and the discharge control FET **105** in response to the outputs of the voltage detection circuits **102** and **103**, and an intermediate terminal disconnection detecting circuit **211**.

The operation of the related art battery device will next be described.

When a voltage generator such as a charger is connected between the external terminals **112** and **113** to charge the secondary batteries **107***a* and **107***b*, the voltage detection circuit **102** outputs a detection signal to the control circuit **204** when the voltage of the secondary battery **107***a* reaches a predetermined voltage or higher set by the voltage detection circuit **102**. Then, the control circuit **204** having received the signal therein outputs a signal for turning off the charge control FET **106** to turn off the charge control FET **106** to thereby avoid a charging current from flowing and thereby controls the secondary battery **107***a* so as to prevent its overcharging.

When a load such as a resistor is connected between the external terminals **112** and **113** to discharge the secondary batteries **107***a* and **107***b*, the voltage detection circuit **102** outputs a detection signal to the control circuit **204** when the voltage of the secondary battery **107***a* becomes a different predetermined voltage or less set by the voltage detection circuit **102**. Then, the control circuit **204** having received the signal therein outputs a signal for turning off the discharge control FET **105** to turn off the discharge control FET **105** to thereby avoid a discharging current from flowing and thereby controls the secondary battery **107***a* so as to prevent its overdischarging.

The intermediate terminal disconnection detecting circuit **211** is set to supply more current than the current flowing through the voltage detection circuit **102**. When the connection between the intermediate terminal **109** and the secondary battery **107** is disconnected, the voltage of the intermediate terminal **109** is pulled up by the intermediate terminal disconnection detecting circuit **211**. Accordingly, the difference in voltage between the intermediate terminal **109** and the negative power supply connection terminal **110** becomes large. When it becomes a predetermined voltage or higher set by the voltage detection circuit **103**, the voltage detection circuit **103** detects an intermediate terminal disconnection and outputs its signal to the control circuit **204**. Since the intermediate terminal disconnection can be detected by providing the intermediate terminal disconnection detecting circuit **211** in this manner, it is possible to provide a high safety battery device (refer to, for example, FIG. 1 in Japanese Unexamined Patent Application Publication No. Hei 8(1996)-308115).

In the conventional charge/discharge control circuit and battery device, however, a difference occurs between current consumed by the secondary battery **107***a* and current consumed by the secondary battery **107***b* due to the current flowing through the intermediate terminal disconnection detecting circuit **211**. A problem arose in that since this current difference became an unbalance current for each secondary battery to be connected and caused the balance between battery voltages to collapse, the service life of the battery device would be shortened.

## SUMMARY OF THE INVENTION

The present invention has been devised to solve the problems described above, and achieves a charge/discharge control circuit and a battery device capable of detecting an intermediate terminal disconnection without causing the balance between battery voltages to collapse and shortening the service life of the battery device.

In order to solve the related art problems, a charge/discharge control circuit and a battery device according to the present invention have the following configuration.

There are provided at least, a positive power supply connection terminal, an intermediate terminal and a negative power supply connection terminal respectively connected with a positive electrode terminal, an inter-battery connection terminal and a negative electrode terminal of each of a

plurality of secondary batteries connected in series; intermediate terminal disconnection detecting circuits each allowing a detection current to flow by switching at every predetermined time between the positive power supply connection terminal and the intermediate terminal, between the intermediate terminals adjacent to each other and between the intermediate terminal and the negative power supply connection terminal; a plurality of voltage detection circuits respectively connected in parallel with the secondary batteries; a control circuit inputted with outputs of the voltage detection circuits; and an intermediate terminal disconnection control circuit that controls the intermediate terminal disconnection detecting circuits.

According to the present invention, the intermediate terminal disconnection detecting circuits are switched by the switches at intervals of constant time to make the same the times during which the intermediate terminal detecting circuits are being connected to the secondary batteries, whereby the time during which an unbalance current for each secondary battery flows becomes the same. As a result, the unbalance current for all the secondary batteries can be cancelled on the time average. Further, it is possible to prevent the balance between battery voltages from being lost and prevent the service life of the battery device from being shortened.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a circuit diagram of a battery device equipped with a charge/discharge control circuit according to a first embodiment;

FIG. **2** is a circuit diagram of a battery device equipped with a charge/discharge control circuit according to a second embodiment; and

FIG. **3** is a circuit diagram of a charge/discharge control circuit and a battery device of related art.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will hereinafter be described with reference to the accompanying drawings.

### First Embodiment

FIG. **1** is a circuit diagram of a battery device equipped with a charge/discharge control circuit according to a first embodiment. The battery device includes secondary batteries **107***a* and **107***b*, a charge control FET **106**, a discharge control FET **105**, external terminals **112** and **113**, and a charge/discharge control circuit **101**. The charge/discharge control circuit **101** includes a positive power supply connection terminal **108**, an intermediate terminal **109**, a negative power supply connection terminal **110**, an intermediate terminal disconnection detecting circuit **125**, an intermediate terminal disconnection detecting circuit **118**, a voltage detection circuit **102**, a voltage detection circuit **103**, and a control circuit **104** having an intermediate terminal disconnection control circuit **115**. The intermediate terminal disconnection detecting circuit **125** is composed of a constant current source **111** and a switch **116**. The intermediate terminal disconnection detecting circuit **118** is composed of a constant current source **114** and a switch **117**.

The secondary battery **107***a* has a positive power supply connected to the external terminal **112** and the positive power supply connection terminal **108**, and a negative power supply connected to the intermediate terminal **109**. The secondary battery **107***b* has a positive power supply connected to the intermediate terminal **109**, and a negative power supply connected to the negative power supply connection terminal **110** and the discharge control FET **105**. The voltage detection circuit **102** is connected between the positive power supply connection terminal **108** and the intermediate terminal **109**. The voltage detection circuit **103** is connected between the intermediate terminal **109** and the negative power supply connection terminal **110**. The control circuit **104** is inputted with the outputs of the voltage detection circuits **102** and **103**. The outputs of the control circuit **104** are connected to a gate of the charge control FET **106** and a gate of the discharge control FET **105** respectively. The charge control FET **106** and the discharge control FET **105** are connected between the negative power supply of the secondary battery **107***b* and the external terminal **113**. The intermediate terminal disconnection detecting circuit **125** is connected between the positive power supply connection terminal **108** and the intermediate terminal **109**. The intermediate terminal disconnection detecting circuit **118** is connected between the intermediate terminal **109** and the negative power supply connection terminal **110**.

The voltage detection circuit **102** monitors the voltage between the positive power supply connection terminal **108** and the intermediate terminal **109**. The voltage detection circuit **103** monitors the voltage between the intermediate terminal **109** and the negative power supply connection terminal **110**. In response to the outputs of the voltage detection circuits **102** and **103**, the control circuit **104** outputs signals for controlling the charge control FET **106** and the discharge control FET **105**. The intermediate terminal disconnection control circuit **115** controls turning-on/off of the switches **116** and **117** by a control signal. The constant current source **111** pulls up the intermediate terminal **109** when the intermediate terminal **109** and each secondary battery are disconnected, i.e., an intermediate terminal disconnection occurs. The constant current source **114** pulls down the intermediate terminal **109** when the intermediate terminal **109** and each secondary battery are disconnected, i.e., an intermediate terminal disconnection occurs. The constant current sources **111** and **114** supply an equal current.

The operation of the battery device equipped with the charge/discharge control circuit according to the first embodiment will next be described.

When the charge/discharge control circuit **101** is monitoring the voltages of the secondary batteries **107***a* and **107***b*, the intermediate terminal disconnection control circuit **115** controls to turn on the switches **116** and **117** alternately for a predetermined time. When the switch **116** is turned on and the switch **117** is turned off, the constant current source **111** is connected between the positive power supply connection terminal **108** and the intermediate terminal **109**. Also, when the switch **116** is turned off and the switch **117** is turned on, the constant current source **114** is connected between the intermediate terminal **109** and the negative power supply connection terminal **110**.

When the switch **116** is turned on when the intermediate terminal **109** and each secondary battery are disconnected, i.e., the intermediate terminal disconnection occurs, the intermediate terminal **109** is pulled up by the constant current source **111** so that the difference in voltage between the intermediate terminal **109** and the negative power supply connection terminal **110** becomes large. Accordingly, the voltage detection circuit **103** detects the intermediate terminal disconnection when the inter-terminal voltage becomes

a predetermined voltage or higher, and turns off the charge control FET **106**. Further, when the switch **117** is tuned on when the intermediate terminal disconnection occurs, the intermediate terminal **109** is pulled down by the constant current source **114** so that the difference in voltage between the positive power supply connection terminal **108** and the intermediate terminal **109** becomes large. Accordingly, the voltage detection circuit **102** detects the intermediate terminal disconnection when the inter-terminal voltage becomes the predetermined voltage or higher, and turns off the charge control FET **106**.

As described above, since the currents of the constant current source **111** and the constant current source **114** are equalized, and the times required to turn on the switches **116** and **117** are set equal, the currents flowing from the second battery **107***a* and the second battery **107***b* become equal to each other, thus making it possible to make equal influences on each secondary battery by the intermediate terminal disconnection detecting circuits.

Incidentally, the switches **116** and **117** may be controlled so as to be turned on by providing a period during which the switches **116** and **117** are both turned off, that is, leaving a predetermined interval in between. By controlling the switches in this way, it is possible to further reduce the time during which an unbalance current flows, and cancel the unbalance current on the time average by switching between the switches **116** and **117**. At this time, the predetermined time or interval during which the switches **116** and **117** are turned on may be designed appropriately.

Although each intermediate terminal disconnection detecting circuit has been described as having the equal constant current sources and the equal on times, they may be set even in whatever form if the total amounts of detection currents flowing therethrough are equal.

The constant current sources are used with the intermediate terminals as pull-up and pull-down means, but are not limited thereto. Further, although a description has been made of the case where the two secondary batteries are connected, the number of secondary batteries is not limited thereto.

As described above, the battery device equipped with the charge/discharge control circuit according to the first embodiment is capable of canceling the unbalance current by the intermediate terminal disconnection detecting circuits on the time average and solving imbalance in battery voltage to lengthen the service life of the battery device.

## Second Embodiment

FIG. **2** is a circuit diagram of a battery device equipped with a charge/discharge control circuit according to a second embodiment. An intermediate terminal disconnection detecting circuit **123** employed in the second embodiment includes a constant current source **124** and switches **119**, **120**, **121** and **122**.

The switch **119** has one terminal connected to the positive power supply connection terminal **108** and the other terminal connected to one terminal of the constant current source **124**. The other terminal of the constant current source **124** is connected to one terminal of the switch **122**. The other terminal of the switch **122** is connected to the negative power supply connection terminal **110**. The switch **121** has one connection terminal connected to a connecting point of the switch **119** and the constant current source **124**, and the other terminal connected to the intermediate terminal **109**. The switch **120** has one connection terminal connected to a connecting point of the switch **122** and the constant current source **124**, and the other terminal connected to the intermediate terminal **109**.

The operation of the battery device equipped with the charge/discharge control circuit according to the second embodiment will next be described.

When the charge/discharge control circuit **101** is monitoring the voltages of the secondary batteries **107***a* and **107***b*, the intermediate terminal disconnection control circuit **115** controls to turn on the switches **119** and **120** and the switches **121** and **122** alternately for a predetermined time. When the switches **119** and **120** are turned on and the switches **121** and **122** are turned off, the constant current source **124** is connected between the positive power supply connection terminal **108** and the intermediate terminal **109**. Also, when the switches **119** and **120** are turned off and the switches **121** and **122** are turned on, the constant current source **124** is connected between the intermediate terminal **109** and the negative power supply connection terminal **110**.

When the switches **119** and **120** are turned on when the intermediate terminal **109** and each secondary battery are disconnected, i.e., the intermediate terminal disconnection occurs, the intermediate terminal **109** is pulled up by the constant current source **124** so that the difference in voltage between the intermediate terminal **109** and the negative power supply connection terminal **110** becomes large. Accordingly, the voltage detection circuit **103** detects the intermediate terminal disconnection when the inter-terminal voltage becomes a predetermined voltage or higher, and turns off the charge control FET **106**. Further, when the switches **121** and **122** are turned on when the intermediate terminal disconnection occurs, the intermediate terminal **109** is pulled down by the constant current source **124** so that the difference in voltage between the positive power supply connection terminal **108** and the intermediate terminal **109** becomes large. Accordingly, the voltage detection circuit **102** detects the intermediate terminal disconnection when the inter-terminal voltage becomes the predetermined voltage or higher, and turns off the charge control FET **106**.

As described above, since the times during which the switches **119** and **120** and the switches **121** and **122** are turned on are set equal by the common constant current source **124**, and the intermediate terminal disconnection is detected, the currents flowing from the second battery **107***a* and the second battery **107***b* become equal to each other, thus making it possible to make equal influences on each secondary battery by the intermediate terminal disconnection detecting circuit **123**.

Incidentally, each switch may be controlled to be turned on with a predetermined interval left therebetween. By controlling the switches in this way, it is possible to further reduce the time during which an unbalance current flows, and cancel the unbalance current on the time average. At this time, the predetermined time or interval during which each switch is turned on may be designed appropriately.

Although each intermediate terminal disconnection detecting circuit has been described as having the equal constant current source and the equal on time, it may be set even in whatever form if the total amounts of detection currents flowing therethrough are equal.

The constant current source has been used with the intermediate terminal as pull-up and pull-down means, but is not limited thereto. Further, although a description has been made of the case where the two secondary batteries are connected, the number of secondary batteries is not limited thereto.

As described above, the battery device equipped with the charge/discharge control circuit according to the second embodiment is capable of canceling the unbalance current by the intermediate terminal disconnection detecting circuit on the time average and solving imbalance in battery voltage to lengthen the service life of the battery device.

What is claimed is:

**1**. A charge and discharge control circuit comprising at least:

a positive power supply connection terminal;

an intermediate terminal;

a negative power supply connection terminal respectively connected with a positive electrode terminal;

an inter-battery connection terminal and a negative electrode terminal of each of a plurality of secondary batteries connected in series;

intermediate terminal disconnection detecting circuits each allowing a detection current to flow by switching at every predetermined time between the positive power supply connection terminal and the intermediate terminal, between the intermediate terminals adjacent to each other and between the intermediate terminal and the negative power supply connection terminal;

a plurality of voltage detection circuits respectively connected in parallel with the secondary batteries;

a control circuit inputted with outputs of the voltage detection circuits;

wherein the control circuit comprises an intermediate terminal disconnection control circuit that controls the intermediate terminal disconnection detecting circuits.

**2**. The charge and discharge control circuit according to claim **1**, wherein each of the intermediate terminal disconnection detecting circuits is controlled by a signal from the intermediate terminal disconnection control circuit and has a period during which the detection current is made not to flow.

**3**. The charge and discharge control circuit according to claim **1**, wherein the intermediate terminal disconnection detecting circuits are provided in plural form in parallel with the voltage detection circuits respectively.

**4**. A battery device comprising:

a plurality of secondary batteries connected in series;

a charge and discharge control circuit, which controls charge and discharge of the secondary batteries; and

charge and discharge control switches each controlled by the charge and discharge control circuit;

wherein the charge and discharge control circuit comprises:

a positive power supply connection terminal, an intermediate terminal and a negative power supply connection terminal respectively connected with a positive electrode terminal, an inter-battery connection terminal and a negative electrode terminal of each of a plurality of secondary batteries connected in series;

intermediate terminal disconnection detecting circuits each allowing a detection current to flow by switching at every predetermined time between the positive power supply connection terminal and the intermediate terminal, between the intermediate terminals adjacent to each other and between the intermediate terminal and the negative power supply connection terminal;

a plurality of voltage detection circuits respectively connected in parallel with the secondary batteries;

a control circuit inputted with outputs of the voltage detection circuits;

wherein the control circuit comprises an intermediate terminal disconnection control circuit that controls the intermediate terminal disconnection detecting circuits.

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